Engineering education and concept of 'Bildung'

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ABSTRACT

Since a couple of decades many engineering education programs focus on engineering capabilities and on how knowledge will be used rather than on engineering knowledge per se. Communication, leadership and ethics are among these capabilities. Bildung the ability to integrate humanistic aspects and points of view is not. The Royal Institute of Technology is now considering the introduction of Bildung into the engineering education. What is Bildung and what is it expected to bring to bring to engineering education? This paper uses a pragmatic method and tries to define Bildung by giving examples from situations where Bildung comes into expression. Some of its implications are discussed. One conclusion is that knowledge building in humanities adds new and pregnant perspectives to technical knowledge. Students who are able to apply wide general knowledge ('Bildung') to engineering problems and situations are able to bring new aspects to their critical thinking. One argument is that engineering students should be exposed to Bildung in order to strengthen their integrity, independent thinking and responsibility.

KEYWORDS

Bildung, critical thinking, internalization, communication.

1. BACKGROUND

The Royal Institute of Technology, (KTH) Stockholm, Sweden has initiated a study in 2008 of a project designed to deepen understanding around a few key engineering capabilities. The proposal is that these capabilities would be demonstrated by all students graduating from KTH. Six areas where capabilities must be shown have been identified: Innovation and entrepreneurship, Sustainable development, Internationalization, Cooperation with society, Communication and Bildung in engineering.

Five of the above mentioned capabilities are more or less included in the CDIO-syllabus which has been adopted by many engineering programs. The fifth one Bildung in engineering science is not yet. It is this capability and the need for its inclusion in the list of graduate capabilities which is the focus of discussion in this paper.

Some questions may be reasonable to ask. (i) What is 'Bildung' and what is it expected to bring to engineering education? (ii) In what situations in the professional life of engineers will competencies drawing upon 'Bildung'-type decision making come into expression? (iii) How can 'Bildung' be taught and assessed?

2. METHOD

The method used in the current paper is pragmatic i. e. to give concrete examples before discussing the general concepts they represent. Concepts in the natural language have different meanings in different situations and for different people. [1] It is therefore necessary to give an example to narrow the interpretation of the concept and make the communication more efficient and reliable. Thus, I will try to identify some situations in engineering practice, where the capability of Bildung is involved and discuss its implications.

3. WHAT IS BILDUNG AND WHAT IS IT EXPECTED TO BRING TO ENGINEERING EDUCATION?

3.1. WHAT IS BILDUNG?

The concept of Bildung is not easily defined. Among others things it has to do with the capability to include many perspectives in one's decision, be aware of the limits of the knowledge one represents and the preconceptions one harbours. None the less we can say a lot about Bildung, many times by giving examples when such capability comes into expression in real life.

As a broad understanding Bildung can be seen as the capability of an individual to think by him or herself and to make well grounded judgments on a lot of human related endeavours. As such Bildung can be seen as a capability that adds new layers to technical rationality. If technical rationality is about what can be modelled and computed Bildung is about what is complex and doesn't lend itself to this kind of information processing just because it belongs to a complex domain that should be dealt with holistically. Many phenomena in this domain are not deterministic nor can they be reduced. In the complex domain knowledge, capabilities as well as emotions have to be considered to meet the demands of a specific situation before making decisions. [2]

3.2. CRITICAL THINKING

It goes without saying that the capability of assessing knowledge and performance in any domain requires a mastery of that very domain whether it is technology or art. It is only the one who masters the knowledge or skill domains that is able to tell what is lacking a performance to improve its quality. This kind of critique may be perceived as a critique from inside a paradigm.

Most engineering problems on the other hand are of practical nature. They are about acting in the world, about defining and solving technical systems. Attention is most of the time concentrated on *What* the problem is and *How* it should be solved. Sometimes it is however necessary to ask *Why, for whom* and *what* are the consequences of the solutions proposed. This kind of critical thinking may be characterized as from outside the paradigm and some times even be seen as controversial. None the less this is the kind of questions that many engineers have to deal with each time they apply for a new position in industry or undertake a project.

Another aspect of critical thinking has to do with a critical attitude towards the view implicit in ones own education, how problems are defined and solved and with what methods. Even Science and technology have their limits. [3] Intuition for instance plays a major role in creating hypothesis, designing systems as well as communicating results to others.

3.3. INTERNATIONALIZATION

The work market for engineers has in the last few decades become more and more global. But what new challenges does this new situation demand from young engineers?

In international situations where cultures come together the problem of interpretation and common understanding is even more acute. It may be at home with foreign professionals or abroad where one is foreign to the culture and where communication's patterns are different from what we are used to. To be aware of one's preconceptions is at least to partly dominate them and act to minimize their negative effects on our behaviour. It is however in reflection together with others that you may develop these capabilities.

It is hardly feasible to learn about all the cultures in the world. What is realistic is reflect and learn from a few examples to become aware of one's own culture and the preconceptions inherent in it to be able to handle intercultural situations properly.

3.4. COMMUNICATION

In engineering education communication is often seen as a number of methods and instruments engineers can use to communicate efficiently. In this model it is presupposed that the information is given and the only existing problem is how to convey efficiently to a specific audience. In some cases this may also be true.

In new situations in the complex knowledge domain like; sustainable development, internationalization and cooperation with the society experts from different domains are engaged. When economists, politicians, scientists, psychologists are involves to reach a common decision in a project, communication may be quite different. The ability to carefully listen to others points of view is crucial. To act like there is only one solution to the problem at hand may sometimes be rather contra-productive and may give rise to unforeseeable conflicts. A dialogical approach to the truth and a sense of compromise is much more suitable for reaching sustainable solutions.

Many of the concepts used especially in the complex domain are contested. [4] Experts from different domains have different views on them which complicate every consensus attempt. What are the causes of the global warming and what should be done to prevent it and save the world are no easy questions to answer. Even expert in the same domain may disagree on causes and effects of different phenomena.

3.4.1. Interpretation: The only way of making sense?

Recently a teacher participating in reflective seminars declared that apparently easy concept that he almost uses daily in ship design courses like the ship should have "satisfying properties and performance" have become quite difficult to deal with. Each time he re-examined a concept somewhat closely he became aware how elusive the concept is and each definition makes even more difficult to understand. [5]

Another professor responsible for the doctoral students declared that the written rules regulating postgraduate studies were clear to him when he was appointed head of doctoral studies ten year ago. With the experience he has acquired it is not the case any longer.

Cases likes these are most of the time around us and can only be seen if we give enough attention to what experience demands from our judgment. When we have experienced many situations that may be categorized under a same rule we realize that the real world is much more complicated than what can be caught in formal rules. The Anglo-Saxon case-law system is an ample example of this phenomenon. In this system rules are created at the same time the court is dealing with specific cases. [4] It is, most of the time, with variation in experience and in contact with concrete and different situations that we learn to detect patterns and develop our judgment.

What these examples suggest is that even apparently easy everyday concepts become complicated when they meet experience and reflection. [6] The same goes for other with other concepts central to engineering activities like ethical behaviour, responsibility and risk assessment for example.

3.5. THE THEORY OF KNOWLEDGE

In mathematics it is easy for a knowledgeable person to establish if a reasoning in true or false. Sciences reduce nature to very small phenomena possible to test in experiences for example pendulum, drop of water on a surface or reflection of the light. This kind of phenomena may be characterized as belonging to a *simple* domain of knowledge. Rules emanating from such experiments are universal and have a predictive power.

Based of this fundamental rules the engineer has to integrate imagination, technology and entrepreneurship to create technical systems to define and solve the needs of individuals, groups and society, cell-phones, power plants, airplanes, bridges etc are created and developed. This knowledge domain is based on science but has many times to count on uncertainties, trial and error, and testing. Unlike science technical systems are not always easy to classify as true or false and there is not only one right answer. More or less efficient systems are maybe better categories to classify them. This knowledge domain may be called a *complicated* knowledge domain.

In big projects like global warming, sustainable development, traffic planning and the like engineers have to work with other professionals i. e. economists, scientists, psychologist, politicians and others to reach durable solutions. Decisions in this domain are of course based on the scientific facts available but even if we are lucking knowledge and there is a lot of uncertainties we have to act sometime based not only on scientific knowledge but also on proven experience. This domain may thus be called a *complex* knowledge domain.

Both in the complicated and the complex knowledge domains engineers act in the world. Systems are created by people for people, operated by people and if broken people may as well suffer from they failures. Technical failures of airplanes, nuclear power plants and space shuttles talk for themselves.

The ability to use the adequate knowledge building perspective in each domain may help avoid more than one misconception. Responsibility, integrity, flexibility, involvement and ethical behaviour are hardly of the kind of abilities that could be developed by methods for experimental or by mathematical modelling.

Decisions in the complex domain require most of the time dialogical skills i.e. to be able to both listen carefully and make sure you interpret your collaborators correctly. It has to do with the ability to perform dialogical skills to avoid conflicts and misunderstanding. It is also to let oneself be convinced of others perspective when found sound. This has to do with the capability to think critically, recognize the limits of one’s own knowledge and learn to discern ethical dilemmas in one’s practice. The real world in its complexity is not always easy to categorize in objective-subjective dichotomies it may prove necessary to open up for intersubjective decisions i.e. consensus decisions. To reach this kind of decisions is to show the “capability” of Bildung.

Scientific knowledge can most of the time be taught in lectures and recitals and assessed by written exams. This presupposes however that answers are given. Theses forms of acquiring knowledge are not always possible with skills or judgment. Here you have no other way of learning that practicing in real situations and getting feedback on your performance.

4. CONCLUSIONS

The situations that the engineer meets in his or her working life can thus be classified into two broad categories requiring knowledge from two different realms: the realm of science and the realm of interpersonal capabilities and values. These two realms require two different

approaches of teaching and assessment. Science is what can objectively be proven and has a predictive power. Interpersonal capabilities and values are what the individual is able of performing and adheres to. Capabilities can be acquired by practice and feedback. Values by identifying dilemmas in engineering practice, discussing their implications, considering the consequences for those involved taking inclusive positions that can ethically be motivated in a social context.
The situations that the engineer meets in his or her working life can thus be classified into two broad categories requiring knowledge from two different realms. The realm of *Having* and the realm of *Being*.

- To *have* the knowledge of mathematics, science and technology and the capability to integrate them to create technical systems
- *Being* involved, responsible, ethical and flexible.

In the simple domain, knowledge and abilities the engineer has, are most of the time enough to cope with the challenges at hand. In most complicated domain and in the complex domain the qualities of *Being* come more to the fore. It is when these two categories are developed and interact in a balanced way with each other that the necessary holistic way of professionalism that may be called Bildung is reached.

Bildung has to with individuals and *how* they use their scientific and technical knowledge. It brings a holistic perspective to engineering makes the engineers able to act in a diverse world in an inclusive, responsible and ethical way. It also guides engineers to help humanity satisfy its needs without denying future generations the possibility to satisfy theirs.

Bildung has thus to be a different perspective that counterbalances technical rationality in order to bring a new holistic perspective of how knowledge and abilities of the engineer should be used. With the increasing challenges in the complex domain, Bildung will be more required to handle engineers' collaboration with other professionals and cultures to reach sustainable solutions.

Bildung can not be taught the same way science is, for there are few universal rules to convey. It has also to do with the ability to develop one's own judgment, ethical behaviour, involvement, responsibility, critical thinking and the like when bringing general rules to specific situations. In a seminar form students are afforded opportunities to reflect about dilemmas in engineering practice to train their integrative capacities and develop the judgment together with others. Motivated, independent and inter-subjective decisions are fundamental aspects of Bildung.

5. REFERENCES

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